

**UNITED STATES PATENT APPLICATION**

**OF**

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**FOR**

**LIQUID CRYSTAL DISPLAY AND FABRICATING METHOD**

This application claims the benefit of Korean Patent Application No. 1999-58748, filed on December 17, 1999, which is hereby incorporated by reference for all purposes as if fully set forth herein.

## **BACKGROUND OF THE INVENTION**

### **Field of the Invention**

The present invention relates to liquid crystal displays. More particularly, it relates to a liquid crystal display, and to a method of fabricating that display, having improved adhesion between a passivation layer and a pixel electrode.

### **Discussion of the Related Art**

Generally, a liquid crystal display (LCD) includes switching devices consisting of thin film transistors, each having a gate electrode, a gate insulating film, an active layer, an ohmic contact layer, and source and drain electrodes. A liquid crystal display further includes a liquid crystal material between a lower plate, provided with pixel electrodes and the switching devices, and an upper plate provided with color filters.

An LCD is comprised of  $N \times M$  pixels, where  $N$  and  $M$  are integers. Each pixel includes a thin film transistor and a pixel electrode that is coupled to the thin film transistor.  $N$  gate lines and  $M$  data lines transmit signals to the gate electrodes and to the drain electrodes of the thin film transistors. The gate lines and data lines are formed in such a manner that they cross. The pixel electrodes beneficially overlap the data lines and the gate so as to increase an aperture ratio of the LCD. At the overlap of each pixel electrode and data

line is a passivation layer. That passivation layer is usually formed from an organic insulator having a small dielectric constant. This reduces a parasitic capacitance between the pixel electrodes and the data lines. Organic materials such as BCB ( $\beta$ -staggered-divinyl-siloxane-benzocyclobutene), acrylic organic compound, or PFCB (perfluorocyclobutane) are common organic insulators.

Figures 1A to 1E illustrate a simplified process of fabricating a conventional LCD. Referring now to Figure 1A, a metal thin film, usually of aluminum (Al) or copper (Cu), is formed on a transparent substrate 11, beneficially by sputtering. The metal thin film is then patterned to form a gate electrode 13. Beneficially, the fabrication of the gate electrode is performed by wet photolithography.

Referring now to Figure 1B, a gate insulating film 15, an active layer 17, and an ohmic contact layer 19 are sequentially formed over the gate electrode 13, beneficially by chemical vapor deposition (CVD). The gate insulating film 15 is beneficially formed from an insulation material, such as silicon oxide or silicon nitride. The active layer 17 is beneficially formed from undoped amorphous silicon or undoped polycrystalline silicon. The ohmic contact layer 19 is beneficially made from an amorphous silicon or a polycrystalline silicon that is doped with an n-type or p-type impurity at a high concentration. The ohmic contact layer 19 and the active layer 17 are then photolithographically patterned using anisotropic etching to expose the gate insulating film 15. However, as shown, the active layer 17 and the ohmic contact layer 19 are left over the gate electrode 13 and over its surrounding area.

Referring now to Figure 1C, a metal layer is then deposited over the resulting structure, beneficially using either CVD or sputtering. In particular, the metal layer is formed

over the ohmic contact layer 19 so as to make electrical contact with the ohmic contact layer 19. Beneficially, the metal layer is comprised of molybdenum (Mo), chrome (Cr), titanium (Ti) or tantalum (Ta), or of a molybdenum alloy such as MoW, MoTa or MoNb. The metal layer is then patterned by photolithography to expose the gate insulating film 15. Additionally, part of the metal layer over the gate electrode 13 and part of the ohmic contact layer 19 is removed, thereby forming a source electrode 21 and a drain electrode 23. Additionally, part of the active layer 17 is exposed. The exposed portion of the active layer 17 becomes a channel.

Referring now to Figure 1D, an organic insulation material having a small dielectric constant, beneficially an acrylic organic compound, BCB or PFCB, or the like, is deposited on the transparent substrate 11, thereby forming a passivation layer 25. In the conventional LCD, the passivation layer 25 has a hydrophobic property. Then, the passivation layer 25 is patterned to define a contact hole 27 that exposes the drain electrode 21. The passivation layer 25 is then dry ashed in a vacuum to transform its surface to have a hydrophilic property.

Referring now to Figure 1E, an indium tin oxide (ITO), tin oxide (TO) or indium zinc oxide (IZO) transparent conductive material is deposited on the passivation layer 25 and into the contact hole 27 such that the transparent conductive material electrically contacts the drain electrode 21. As the surface of the passivation layer 25 has a hydrophilic property, the adhesion between the passivation layer 25 and the transparent conductive material is better than it would be if the surface of the passivation layer was left with a hydrophobic property. Then, the transparent conductive material is patterned by

photolithography, beneficially using an acid mixture such as  $\text{HCl}, (\text{COOH})_2$  or  $\text{HCl} + \text{HNO}_3$  as an etchant, to form a pixel electrode 29.

In the conventional method of fabricating the LCD as described above, first a passivation layer having a hydrophobic property is dry ashed in a vacuum to produce a surface having a hydrophilic property, and then a transparent conductive material is deposited. The transparent conductive material is then patterned. This procedure tends to prevent the pixel electrode from being reduced in size by etching when it is being formed.

While generally successful, the conventional method of fabricating the LCD has a problem. Since the passivation layer must be dry ashed in a vacuum, the fabrication time tends to be rather long because it takes a relatively long time to form a vacuum. Therefore, a way of providing a surface having a hydrophilic property at normal process pressure, usually atmospheric pressure, would be beneficial.

### **SUMMARY OF THE INVENTION**

Accordingly, the present invention is directed to a method of fabricating a liquid crystal display that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method of fabricating a liquid crystal display wherein a buffer layer having a hydrophilic property is provided at the surface of a passivation layer having a hydrophobic property, beneficially when the passivation layer is experiencing normal pressure.

Another object of the present invention is to provide a method of fabricating a liquid crystal display wherein a buffer layer having a hydrophilic property is provided at the

surface of a passivation layer using ultraviolet rays. Beneficially the ultraviolet rays have wavelengths of 100 to 200nm.

Another object of the present invention is to provide a liquid crystal display that includes a buffer layer having a hydrophilic property disposed between a pixel electrode and a passivation layer.

Additional features and advantages of the invention will be set forth in the description that follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a method of fabricating a liquid crystal display includes the steps of forming an organic passivation layer over a thin film transistor on a transparent substrate; patterning the passivation layer to define a contact hole that exposes a drain electrode, and irradiating the surface of the passivation layer using ultraviolet rays so as to produce a buffer layer having a hydrophilic property; and then forming a pixel electrode on the buffer layer such that the pixel electrode electrically contacts the drain electrode through the contact hole.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

### **BRIEF DESCRIPTION OF THE DRAWING**

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

Figures 1A to 1E are sectional views showing a conventional process of fabricating a liquid crystal display; and

Figures 2A to 2E are sectional views showing a process of fabricating a liquid crystal display, as well as the display itself, according to an embodiment of the present invention.

### **DETAILED DESCRIPTION OF THE EMBODIMENT**

Reference will now be made in detail to an embodiment of the present invention, an example of which is illustrated in the accompanying drawings.

Referring now to Figure 2A, a metal thin film, usually of aluminum (Al) or copper (Cu), is formed on a transparent substrate 31, beneficially by sputtering or by coating using an electroless plating technique. The transparent substrate 31 is beneficially of glass, quartz, or a transparent plastic. The metal thin film is then patterned to form a gate electrode 33. Beneficially, the fabrication of the gate electrode is performed by wet photolithography.

Referring now to Figure 2B, a gate insulating film 35, an active layer 37, and an ohmic contact layer 39 are sequentially formed over the gate electrode 33 and over the

transparent substrate 31, beneficially by chemical vapor deposition (CVD). The gate insulating film 35 is beneficially formed from an insulation material, such as silicon oxide or silicon nitride. The active layer 37 is beneficially formed from undoped amorphous silicon or undoped polycrystalline silicon. The ohmic contact layer 39 is beneficially made from an amorphous silicon or a polycrystalline silicon that is doped with an n-type or p-type impurity at a high concentration. The ohmic contact layer 39 and the active layer 37 are then photolithographically patterned using anisotropic etching to expose the gate insulating film 35. However, the active layer 37 and the ohmic contact layer 39 are left over the gate electrode 33 and over its surrounding area as shown in Figure 2B.

Referring now to Figure 2C, a metal layer comprised of molybdenum (Mo), chrome (Cr), titanium (Ti) or tantalum (Ta), etc., or a molybdenum alloy such as MoW, MoTa or MoNb, etc. is deposited on the gate insulating film 35 and ohmic contact layer 39 by CVD or sputtering technique. The metal layer forms an ohmic contact with the ohmic contact layer 39. Then, the metal layer is patterned by the photolithography to expose the gate insulating film 35. Additionally, part of the metal layer over the gate electrode 33 and part of the ohmic contact layer 39 are etched to form a source electrode 41 and a drain electrode 43. Additionally, a portion of the active layer 37 over the gate electrode 33 is exposed as shown in Figure 2C. The exposed portion becomes a channel.

Referring now to Figure 2D, a passivation layer 45 is then formed over the structure shown in Figure 2C. The passivation layer 45 is comprised of an organic insulation material having a small dielectric constant, beneficially an acrylic organic compound, BCB or



The surface of the passivation layer 45 is then irradiated using an ultraviolet (UV) ray having a wavelength of 100 to 200nm. This irradiation is beneficially performed at a normal process (atmospheric) pressure. The irradiation forms a buffer layer 49 on the passivation layer having a thickness of about 10 to 50Å. The buffer layer is comprised of SiO<sub>2</sub> or of another oxide. Prior to irradiating the passivation layer 45 its surface was hydrophobic, having a relatively large contact angle of about 50° to 60° . After irradiation, the external surface is that of the buffer layer 49. The surface of the buffer layer 49 has a relatively small contact angle, typically less than 10° , and thus has a hydrophilic property.

Referring now to Figure 2E, a transparent conductive material, beneficially an indium tin oxide (ITO), a tin oxide (TO) or an indium zinc oxide (IZO), is then deposited on the buffer layer 49 and into the contact hole 47 such that the transparent conductive material electrically contacts the drain electrode 41. Since the buffer layer 49 has a hydrophilic

property, the adhesion between the deposited transparent conductive material and its receiving surface (the exposed surface) is better than it would have been if the buffer layer 49 was not present. The deposited transparent conductive material is then patterned by photolithography using an acid mixture such as  $\text{HCl}(\text{COOH})_2$  or  $\text{HCl}+\text{HNO}_3$  as an etchant to form a pixel electrode 51. As the adhesion between the buffer layer 49 and the transparent conductive material is relatively strong, the pixel electrode 51 is prevented from being overetched and reduced in size.

According to the principles of the present invention, the surface of a passivation layer having a hydrophobic property is irradiated with UV rays having wavelengths of about 100 to 200nm at a normal (atmospheric) pressure to form a buffer layer, beneficially of  $\text{SiO}_2$  or of another oxide. The buffer layer, beneficially having a thickness of about  $10\text{\AA}$  to  $50\text{\AA}$ , has a hydrophilic property. Accordingly, a method according to the principles of the present invention has an advantage that, since a buffer layer having a hydrophilic property is formed on the surface of the passivation layer at normal (atmospheric) pressure, the fabrication time is reduced.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.